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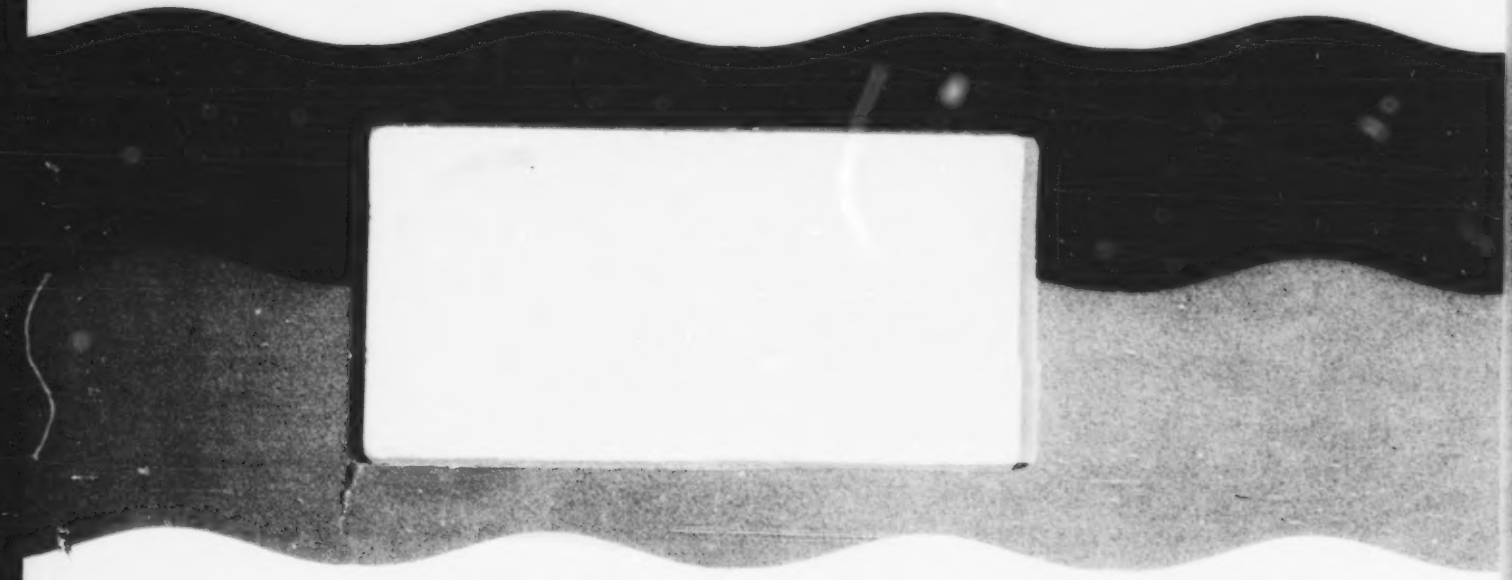

Investigation Report to the Minister pursuant to sections 542 or 545 of the Canada Shipping Act

Rapport d'investigation au Ministre conformément aux articles 542 ou 545 de la Loi sur la marine marchande du Canada

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REPORT OF INVESTIGATION INTO THE CIRCUMSTANCES ATTENDING THE CAPSIZING OF THE CANADIAN UNMANNED BARGE "SEASPAN 240" ALONGSIDE AT THE TILBURY CEMENT LIMITED DOCK, FRASER RIVER, BRITISH COLUMBIA, ON NOVEMBER 25, 1986

REPORT No. 503

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REPORT OF INVESTIGATION INTO THE CIRCUMSTANCES ATTENDING THE CAPSIZING OF THE CANADIAN UNMANNED BARGE "SEASPAN 240" ALONGSIDE AT THE TILBURY CEMENT LIMITED DOCK, FRASER RIVER, BRITISH COLUMBIA, ON NOVEMBER 25, 1986.

Particulars of Vessel

Name	"SEASPAN 240" (ex. "ISLAND IMPORTER")
Official Number	318661
Port of Registry	Victoria, B.C.,
Gross Tonnage	5,886
Register Tonnage	5,875
Length Overall	109.65 m (359.75 ft)
Breadth	22.86 m (75.0 ft)
Depth	7.62 m (25.0 ft)
Draughts (calculated)	
Departure (S.W.)	6.15 m (20.17 ft) Fwd 6.43 m (21.09 ft) Aft
Arrival (F.W.)	6.33 m (20.77 ft) Fwd 6.58 m (21.58 ft) Aft
Type	Non-self-propelled barge
Material	Steel
Built	1962, Esquimalt, B.C.,
Cargo	Limestone rock
Crew	Unmanned
Shoreworkers	Two
Classification	Lloyd's Register of Shipping
Owner	Seaspan International Ltd., North Vancouver, B.C.,
Shipper	Tilbury Cement Ltd., Delta, B.C.

The arrangement of the "SEASPAN 240" is shown in Figure 1. The hull is subdivided by transverse and longitudinal watertight bulkheads to form twenty-three compartments, including

an athwartship void space aft and the forepeak space which contains the ballasting pump room. The centreline compartments are designed for use as ballast tanks and the port and starboard compartments are void spaces. Access to the ballast tanks and void spaces is by way of bolted and gasketted manhole covers installed at various locations in the deck outside the cargo box. Except for the forepeak space, all the compartments have sounding pipes fitted with screwed plugs, and the ventilation pipes for the centreline compartments are permanently blanked off. On the starboard side amidships there is a deck-house/hopper for the onboard conveyor and just aft of amidships is fitted a side wall portal.

The International Load Line Certificate (1966) in force at the time of the casualty was initially issued on December 21, 1984, reissued February 20, 1986, and valid until October 25, 1989. The latest periodical survey prior to the casualty was carried out by Lloyd's on October 9, 1986, and was duly recorded on the load line certificate.

The "SEASPAN 240", operating as an unmanned barge and not carrying pollutants, is not subject to inspection by the Ship Safety Branch, Canadian Coast Guard.

Note: All times mentioned in this report are Pacific Standard Time, i.e. (UTC minus 8 hours)

Background

The "SEASPAN 240" was loaded with 12,651 short tons (11,480 tonnes) of limestone rock at Blubber Bay, Texada Island, on November 17, 1986, towed to the Fraser River by the "SEASPAN CORSAIR" and berthed at the Tilbury Cement Limited dock, Tilbury Island (see photograph No.1), on November 18, 1986.

The cargo would normally have been unloaded immediately, or within a short time after arrival, but on this occasion there was no urgency to unload and the barge remained at the dock with the cargo intact for almost seven days.

In preparation for unloading on November 25, 1986, a counterbalanced roadway ramp was lowered to rest on top of the starboard side wall of the barge and two vehicles (front end loaders) were driven up the ramp and aboard the barge to level out the peaks of the limestone rock. The levelling operation was completed by about 1100 and at 1130, prior to any unloading of cargo and while one of the vehicles was being driven off the barge and down the ramp, the barge heeled to starboard and capsized onto the dock.

The barge was extensively damaged and the dock was partially destroyed (see photographs Nos.2 and 3), but no person suffered physical injury and there was no pollution of the waters.

The "SEASPAN 240" was salvaged and repaired at a cost of approximately $1,500,000.00 and returned to service. The dock was rebuilt and equipment repaired at a cost of approximately $2,500,000.00 and the facility resumed normal operations in mid-April 1987.

Narrative

The "SEASPAN 240" arrived at the loading terminal at Blubber Bay, Texada Island, at about 0800, November 17, 1986, and freeboard measurements of the empty barge were taken prior to loading. The measurements showed that the barge had a barely perceptible starboard list which, when compared to measurements taken in the Fraser River, was slightly less than the list existing after unloading and prior to departure from the cement plant on Tilbury Island on November 16.

Limestone rock had been crushed at Blubber Bay during the three days immediately prior to the arrival of the "SEASPAN 240" and there had been a light rainfall of less than 6 mm (0.25 in) while the rock was stockpiled. Loading of the "SEASPAN 240" started at about 0900, November 17, and continued through the day when the rainfall was approximately 18 mm (0.75 in). Reportedly, the rock was screened to a size of 140 mm (5.5 in) and less, including a certain proportion of fine material, and when loaded was not unduly wet.

Loading of the "SEASPAN 240" was completed at about 2200, November 17, and freeboard measurements were taken at the loading terminal prior to departure. The measurements showed that the barge was virtually upright and a mean freeboard of 1.04 m (3.4 ft) from the deck line indicated there was a limestone rock cargo of 12,651 short tons (11,480 tonnes) on board.

The "SEASPAN CORSAIR" was assigned to tow the "SEASPAN 240" and, after the skipper of the towboat satisfied himself that the barge was appropriately loaded and appeared to be in a seaworthy condition for the intended voyage, the vessels departed Blubber Bay at 2235, November 17.

During the voyage southwards through the Strait of Georgia, south-easterly gale force winds, rising occasionally to storm force, were encountered and the visibility was approximately 5 miles in rain. Due to the combination of wind, rough seas and heavy swell, the vessels proceeded only

some 18 miles during the first eight hours of the voyage. The environmental conditions moderated considerably by about 0700, November 18, and the vessels completed the remaining 48 miles of the voyage to Sand Heads in approximately nine hours. Apart from encountering bad weather at the start of the voyage, when the barge rolled heavily and was taking heavy spray, there were no problems during the tow and the vessels arrived at the cement plant on Tilbury Island at 2035, November 18.

The "SEASPAN 240" was berthed at the cement plant dock in the main stream of the Fraser River adjacent to six concrete pile dolphins with flush wood facings and integral concrete platforms connected by walkways (see photograph No.1), The berthing operation followed a standard procedure for attachment of the mooring lines and for positioning of the barge relative to the unloading conveyor structure using the forward and after main springs led to hydraulically operated winches on the dolphins. The hydraulic winches were shut down after berthing and the designed mooring arrangement permitted the barge to rise and fall freely on the tides with a minimum of attention to the lines. The barge was secured with her starboard side towards the dock and her bow in the upstream direction.

The "SEASPAN 240" would normally have been unloaded shortly after arrival but on November 18 the limestone rock was not immediately required by the cement plant. Consequently, the freeboard measurements which would normally have been taken on arrival, to determine the amount of limestone rock delivered, were not checked on November 18.

On November 19, as the barge was expected to remain alongside in the loaded condition for a few days, the mooring lines were checked and repaired or replaced as found necessary by the cement plant personnel. Plant procedures required that, during a 24 hour period, the mooring lines be checked and if necessary adjusted at least twice during each eight hour shift. The same day, representatives of the shipper and the owner visited the dock and viewed the loaded "SEASPAN 240". They observed nothing unusual in the state of the barge and noted that the load was the second largest cargo to have been carried by the barge.

On November 24, at about 1230, the owner's barge supervisor visited the dock to check the "SEASPAN 240" in the course of his regular duties. He noted that the mooring lines were secure and properly arranged, the cargo was nicely loaded, and the barge had no list and was trimmed slightly by the stern.

From November 18 to 25, the maximum range of tide had been approximately 2.5 m (8 ft) on November 19 and the highest tide of approximately 3.25 m (10.7 ft) had occurred the same day. During the same period the flow rate of the Fraser River was, reportedly, approximately half of the normal predicted rate and, consequently, the speed of the current was less than normal. The rainfall for the area over the same period was some 152 mm (6 in) and the winds had, at the most, been moderate.

On November 25, shift workers at the cement plant had checked the mooring lines for the "SEASPAN 240" at about 0230 and 0630, approximately three hours before and one hour after low tide, respectively. The lines had not needed adjustment on either occasion and the barge was observed to have had no unusual list. After the shift change at 0800, the oncoming plant personnel were directed to prepare the barge for unloading.

At about 0830, November 25, the drivers of the two vehicles (front end loaders) to be used in the unloading operation arrived at the dock. Following normal procedures, the first duties for the drivers were to measure the freeboards from the deck of the barge at three designated points port and starboard, and to obtain a sample of the limestone rock. Also, by operation of the hydraulic winches, the barge was required to be moved 3 to 4 ft ahead that day to the correct position for unloading.

The freeboard measurements which had been taken indicated to the drivers that the barge had an unusual starboard list, with the differences in measurements being 1.13 m (3.75 ft) and 0.98 m (3.2 ft) forward and amidships, respectively, and 0.18 m (0.6 ft) aft. At about 0900, the shift supervisor was at the adjacent dock and, on glancing at the stern of the "SEASPAN 240", observed a slight starboard list of an amount approximately equal to the difference in measurements aft of 0.18 m (0.6 ft).

At about 0855, the counterbalanced roadway ramp was lowered and extended to rest on the top of the starboard side wall of the barge and the first vehicle was driven on to the barge (see photograph No.4). The vehicle proceeded to the forward end of the barge pushing the rocks ahead and forming a pathway from which to work. The second vehicle was driven aboard a few minutes later and proceeded in a similar manner towards the after end of the barge. The vehicles were then parked on board and the drivers walked back to the dock to attend to the roadway ramp and the conveyors.

The ramp was raised and pins were inserted which secured

the ramp in the raised position. The counterbalanced shore conveyor structure was lowered into position on the deck of the barge at the starboard side and, after the barge's electrical power extension cables were connected ashore, the onboard conveyor was moved into position to overlap the shore conveyor (see photograph No.5). The drivers then returned to their vehicles on board the barge by way of ladders on the dock and the barge.

At about 0915 the drivers started to operate their vehicles to level out the athwartship ridges of rock formed when the barge was loaded and, at the same time, shape additional athwartship ridges to act as safety fenders at the forward and after ends of the load. The levelling process was carried out to facilitate movement of the vehicles while transporting rock to the conveyor house/hopper during unloading. The drivers reported that, as was normally the case, they were aware of some small list during the levelling and unloading operations and of some rolling of the barge due to the continuous movement of the vehicles. Reportedly, as the rock was levelled, it was left slightly higher at the port side to prevent any further increase of the previously noted starboard list.

Levelling of the ridges at the forward end of the barge was finished at about 0940 but had not been completed at the after end when both drivers walked ashore for a coffee break at about 0955. After the drivers returned to the barge at about 1015 the driver of the vehicle at the forward end sat in his vehicle while the driver of the vehicle at the after end completed the levelling in that area. The levelling process was finished by about 1100 and both drivers then sat in their vehicles, one forward and one aft, awaiting the start of the conveyor system so that they could begin the unloading.

In the meantime, the shift supervisor visited the dock area alongside the "SEASPAN 240" at about 1050 to collect the rock sample obtained earlier by the drivers. While at the dock, he advised the drivers that a breakdown in the plant would likely cause a delay in the unloading and was the reason that the conveyors had not been started. The supervisor left the dock at about 1055 and reportedly, had noticed nothing unusual with regard to the disposition of the rock or the attitude of the barge.

Also, from about 1040 to 1110, two members of the cement plant safety committee were on the dock alongside the "SEASPAN 240" to carry out a routine safety inspection of the dock area. Both persons observed that the barge had a starboard list, to the extent that the top of the deck amidships

on the starboard side was approximately 356 mm (14 in) above the water, and that the underside of the conveyor structure framework was in the water. One person reportedly observed water draining off the deck of the barge at the after end on the starboard side and that the top of the starboard side wall of the barge was at the same level as the top of the dock.

The shift supervisor returned to the dock at about 1125 to assign other duties to the drivers until the breakdown ashore was resolved. The two vehicles were driven to the starboard side of the barge for the drivers to receive instructions from the supervisor and one driver walked ashore to speak with the supervisor. When the supervisor departed at about 1130 there was, reportedly, no appearance of anything unusual about the way the rock had been levelled or of any excessive list to the barge.

The drivers were instructed to drive the vehicle from the after end of the barge ashore and to proceed to another assignment in the plant. The driver already on shore lowered and extended the roadway ramp in preparation for disembarkment of the vehicle and walked back aboard to relay the instuctions to the driver of the vehicle at the after end. While that vehicle was used to build a rock ramp to drive over the side wall, the other driver secured his vehicle approximately on the centre of the load forward and walked back to the operating controls on the roadway ramp to await disembarkation of the vehicle from the after end of the barge.

As the vehicle from the after end was driven over the side wall, and as all the wheels came on to the roadway ramp, the drivers observed that the barge was heeled to starboard, such that the edge of the deck amidships was level with the water, and heard the noise of rocks tumbling against the inside of the starboard side wall and then saw a few rocks roll over the top of the side wall. The driver at the roadway ramp controls started to raise the ramp while the vehicle was still moving down the ramp but, as the ramp was raised from the side wall, the barge continued to heel slowly to starboard.

When the vehicle was off the ramp and on to the dock, the driver at the ramp controls stayed on the ramp for a few moments to watch the barge and, when he was of the opinion that she was heeling still farther, he ran down the ramp to the dock. The drivers and the vehicle proceeded to transfer tower No.2, approximately 60 m (200 ft) away from the barge, stopped, and radioed to the supervisor to report that the barge was going over.

The vehicle was then driven to the vicinity of the finish mill, approximately 230 m (750 ft) away from the barge, and, reportedly within ten minutes of the barge first starting to heel to starboard, the drivers saw the barge vertical and on her starboard side. At about 1135, all the rock fell from the barge and the inherent buoyancy caused her to leap up in the water and land upside down on the dock.

The operators of the vehicles were the only persons on board the barge and in the immediate vicinity of the dock before and as she capsized, and they escaped injury because as the barge began to heel they were already disembarking and were able to proceed a safe distance away as the barge capsized.

Four dolphins and the connecting walkways were demolished and the roadway ramp, the conveyor structure, the lifting towers and the counterbalance mechanisms, collapsed into the water. The capsized "SEASPAN 240" remained afloat laying at an angle across the dolphins with at least two of her lines intact (see photographs Nos. 2 and 3).

The barge was pulled clear of the dock on November 26, 1986 and towed to Vancouver Harbour the following day, righted on January 21, 1987, and subsequently surveyed and repaired. The debris was removed from the dock area, the dock and equipment rebuilt and repaired, and operations were resumed on April 23, 1987. It was agreed by the owner and the shipper that the load for the "SEASPAN 240" shall in the future be limited to a maximum of 10,750 short tons (9,752 tonnes) to give a mean freeboard from the deck line of approximately 1.8 m (5.8 ft).

Analysis

1. Brief History of Vessel

In 1962, the "SEASPAN 240" was assigned a load line under the International Load Line Convention, 1930, by Lloyd's Register of Shipping (Lloyd's), with a summer freeboard of 5.5 ft (1,676 mm) for coastal service between the Gulf of Georgia and the Columbia River. The assigned freeboard is measured from deck lines marked on the sides of the barge amidships. Due to differences in the thickness of the deck plating these lines are marked 292 mm (11.5 in) and 305 mm (12.0 in) below the top of the deck plate, on the port and starboard sides respectively.

On entering service in 1962, the "SEASPAN 240" was generally used in international trade, on coastal

voyages, carrying cargoes of limestone rock from British Columbia ports in the Strait of Georgia to ports on the Columbia River in Washington and Oregon, U.S.A. Occasional voyages were made from Canadian ports to Tacoma, Washington, with cargoes of iron ore and copper concentrate. The barge was fitted with side and end walls of wood construction approximately 3.2 m (10.5 ft) in height and the cargoes carried on deck. On the starboard side, just aft of amidships, there was a doorway in the side wall to facilitate movement of vehicles used in the working of the barge and, at amidships, a small deck-house above an onboard unloading conveyor which was set at an angle below deck through the centre and starboard side tanks.

In 1970 a load line was assigned under the International Convention on Load Lines, 1966, by Lloyd's, with a summer freeboard of 1,588 mm (5.21 ft). Also, in 1970, stability data was submitted to and approved by the Board of Steamship Inspection, Department of Transport.

The onboard unloading conveyor arrangement was modified in 1975 when the conveyor penetrating the centre and starboard side tanks was removed. Deck plating was fitted above those tanks and a new conveyor was installed above deck inside a new and larger deck-house/hopper structure.

In 1976 the load line assignment was amended by Lloyd's for unrestricted service and, with the addition of tropical and winter freeboards, the summer freeboard was maintained at 1,588 mm (5.21 ft).

The "SEASPAN 240" was on regular coastal services until 1978 when a contract was established between the owner and the shipper for the carriage of limestone rock from Texada Island, in the Strait of Georgia, to the cement plant on Tilbury Island, in the Fraser River. The dock at the cement plant was new and had been designed and constructed for the berthing of certain vessels, including the "SEASPAN 240".

The Load Line Regulations (Sea) do not apply to the "SEASPAN 240" and similar types of vessels when operating on certain specified waters on the west coasts of Canada and the United States of America, including the Strait of Georgia and Puget Sound.

From 1978 to April 1985 the "SEASPAN 240" carried limestone rock cargoes of up to approximately 11,800 short tons (10,700 tonnes), which equates to a freeboard from

the deck line of approximately 1.4 m (4.5 ft). In May, 1985, it was agreed by the shipper and the owner to maximize the cargo deadweight on each trip and the owner determined that, with a mean freeboard from the deck line of 0.9 m (3.0 ft) and 0.15 m (0.5 ft) trim, the barge could safely carry 13,033 short tons (11,823 tonnes).

In August, 1985, the wood side and end walls were removed and steel plate walls approximately 3.7 m (12.25 ft) in height were installed. This modification was surveyed and accepted by Lloyd's and the owner prepared and issued a new deadweight table for the guidance of the shipper. The cargo deadweight determined for a mean freeboard from the deck line of 0.9 m (3.0 ft) was 12,981 short tons (11,776 tonnes).

During the period 1978 to 1986, when not engaged in service under the afore-mentioned contract, the "SEASPAN 240" was used on occasional voyages to ports on Puget Sound, Washington, with similar cargoes of limestone rock. Some eighty deliveries were made under the terms of the contract in 1985, and the maximum cargo deadweight loaded for this purpose was on May 13, 1985, when 12,973 short tons (11,769 tonnes) were transported from Texada Island to the Fraser River.

The following items of this analysis are intended to describe the many features that may have existed at the time of capsizing and to indicate their possible contributing effects to the occurrence:

2. Mooring Arrangement

The dock at the cement plant on Tilbury Island was designed and built over the years 1976 to 1978 and the unloading facility was primarily designed for berthing and unloading the "SEASPAN 240". The mooring arrangement (see Figure 1) was agreed to by the owner and the shipper and designed by consulting engineers. The design calculations indicated that the mooring arrangement would maintain the position of the barge relative to the plant conveyor structure and, with a minimum of attention to the lines, allow the barge to rise without restriction during unloading and to rise and fall freely with the tides.

The forward and after 25.4 mm (1 in) diameter steel spring lines were to be pre-tensioned with a load of approximately 5 tonnes by suitably controlled electric/hydraulic winches on the outermost dolphins. After pre-

tensioning, the winches were to be shut down and the springs held on the brakes of the winches.

A 25.4 mm (1 in) diameter steel bow line and a 19 mm (0.75 in) diameter steel stern line were not required to be pre-tensioned but were to be kept taut. In addition, the height of the bow relative to the dock, while unloading at high tide, required the use of a nylon or polypropylene tail piece on the bow line to guard against breakage of that line.

Evidence indicated that there had been no serious problems with the mooring arrangement over the past eight years of operation and the lines were not generally required to be tended after the barge had been berthed in position and secured. Occasionally lines had been frayed or broken and were repaired or replaced, as required, by the cement plant personnel. About two years before the casualty, due to regular fraying of the steel bow line at the fairlead, the use of the nylon tail piece at the deck bollard had been dispensed with and it was replaced with a steel line attached to a length of chain in way of the fairlead. The original purpose of the nylon tail piece was apparently overlooked.

On November 25, 1986, the 25.4 mm (1 in) forward and after steel spring lines were in place and the steel bow and stern lines were 23 mm (0.875 in) diameter. Their respective breaking strengths were, reportedly, 52 short tons (47 tonnes) and 40 short tons (36 tonnes).

Some cement plant employees apparently received formal instruction on the berthing procedures when the plant started operations in 1978, but since that time it would appear that new employees have received only on the job instruction. It was noted that some of the persons engaged in the berthing and unloading operations for the "SEASPAN 240" were not aware of the pre-tensioning requirements for the spring lines or of the operation of the winches to achieve that condition.

At the time of the casualty the tide was rising and was about one hour before high water. With the barge upright, the spring lines would have been approximately level with, or slightly above, the top of the dock and would have created a small starboard heeling moment on the barge. Similarly, depending on their tautness, the bow and stern lines could have caused small starboard heeling moments. If any, or all, of the lines had been caused to totally restrain the upward movement of the barge they would most likely have broken.

As the barge had risen and fallen on the tide for six days prior to the casualty, with similar tide ranges and with almost no adjustment of the lines, it is not likely that the lines were the sole cause of the capsizing, but in the event could have been a minor contributing factor.

3. Environmental Conditions

Soundings taken in the Fraser River alongside the cement plant dock on July 28, 1986, indicated that there was a depth of water of not less than 9 m (29 ft) at low low water. Therefore, when the "SEASPAN 240" had been raised some 2 m (6 ft) by the tide, it is not likely that the capsizing was associated with a grounding reaction.

From November 18 to 25, while the barge was alongside the dock, there were no exceptional tide ranges, river currents, or winds, and those that did occur were well within the limits of the design criteria for the mooring arrangement.

On a normal turn-round period of about 12 hours, in wet weather conditions, the drainage arrangements (freeing ports) in the side walls of the barge were considered satisfactory because no great amount of water was ever encountered on deck in the final stage of unloading. On this occasion, the barge lay at the dock for over six days when the rainfall was about 152 mm (6 in) and, if none had drained away, approximately 285 short tons (258 tonnes) of water would have accumulated throughout the cargo. If all the drainage holes in the freeing ports were blocked with limestone (see item 5), an accumulation of rain-water of the aforementioned amount within the limestone inside the cargo box could have been a major contributing factor in the listing of the barge and the subsequent capsizing.

4. Limestone Rock Cargo

The limestone rock has a specific gravity of 2.66 and, reportedly, the loaded or packed bulk density can range from 1.6 to 2.6 tonnes per cubic metre (100 to 160 lbs per cubic foot). The rock is crushed and screened prior to loading to a size of 125 mm (5 in) and less, including smaller pieces, and particles commonly referred to as 'fines'. Reportedly, the rock does not absorb water and, when stockpiled or loaded and free to drain, has a water retention factor of from 2 to 5 % due to the surface film and entrappment. As crushed, the rock has an angle of repose of approximately 37.5° and,

reportedly, is stable (i.e. no fluidity) when wet.

During the voyage and while laying for over six days at the dock, it is likely that some of the drainage holes were blocked by small pieces of rock and particles that were compacted into and flushed towards the holes in the freeing ports at the bottom of the side walls. If there had been no drainage (see item 5), and assuming a rock permeability of 20%, the water from the 152 mm (6 in) rainfall would have risen to a height of approximately 0.76 m (2.5 ft) within the rock. Alternatively, during the same period, it is possible that the rock formed barriers or dams within itself and caused some of the water to be retained above the deck.

It is possible that the drainage holes in the freeing ports were totally blocked and, if water was retained on deck and the barge caused to list to starboard, the water would have slowly percolated the rock towards the starboard side and created a heeling moment.

5. Freeing Ports

There are freeing ports port and starboard at the bottom of virtually each panel of the side walls and, due to the nature of the cargo, are an arrangement of forty-nine 38 mm (1 1/2") diameter holes in three rows and two 533 mm x 25 mm (21" x 1") slots at the deck level (see photograph No.6).

The loaded barge was visited on April 29 and November 5, 1987, on arrival at the cement plant, and on both occasions it was observed that the freeing ports were obstructed on the outside of the cargo box. On April 29 the slots at the deck level were blocked, accounting for approximately 33 percent of the freeing port area, and on November 5 the slots and some of the lower two rows of holes were blocked, accounting for approximately 78 percent of the area (see photograph No.7).

The external blockages were in the form of hard and compacted wedges of material, composed mainly of small pieces and fine particles of limestone which had passed through the freeing ports. In addition, pieces of rock were found to be lodged firmly in most of the holes and slots. Reportedly, when the cargo box is empty the holes are free from obstruction internally by the fine particles but the slots remain blocked and the pieces of rock remain lodged in the holes.

That the aforementioned conditions could have arisen

within a period of approximately six months since the barge was returned to service, it is considered to be conceivable that at the time of the casualty the freeing ports may have been ineffective due to being completely blocked in this manner (see photograph No.8).

It would appear likely that blockage of the freeing ports, leading to an accumulation of rain-water inside the cargo box, was a major contributing factor in the capsizing.

6. Damage Survey

The owner and the shipper informed the Canadian Coast Guard of the casualty on November 25, 1986, but the Marine Casualty Investigations Division, Department of Transport, was not advised of the casualty until 1500, November 28, 1986, when notification was received from the Ship Safety Branch, Canadian Coast Guard. Immediate enquiries of the owner and the shipper revealed that no work was to be done on either the barge or the dock pending completion of damage appraisals by the insurance surveyors, and no work was intended to be done over the weekend of November 29 and 30.

The cement plant dock on Tilbury Island was visited on December 1, 1986, and it was observed that dolphins Nos. 8,9,10 and 11, and their interconnecting walkways had been demolished when the barge capsized, and the roadway ramp, the conveyor structure, and the associated lifting towers had collapsed into the water. The ramp, conveyor and lifting mechanisms, including the actuating hydraulic cylinders and rams, were examined at a later date but revealed no evidence as to the cause of the capsizing.

The "SEASPAN 240" was visited in Vancouver harbour on December 4, 1986, and examined while floating in the capsized state. The lower shell and bottom plating was observed to be in excellent condition and showed no evidence of damage that may have occurred prior to capsizing and caused the barge to leak, nor any damage as a result of the capsizing. Prior to attachment of valves and fittings to be used in the salvage operation, all compartments were sounded and starboard side tank No.3 and port side tanks Nos. 2,3,4,6 and 7 were found dry.

The barge was examined after righting and two large sections of the starboard side wall, forward and aft of the conveyor deck-house, and an 8 m (25 ft) section of

the after wall were observed to have been torn away. The main deck plating was buckled as was the adjacent internal structure. Penetration of the deck had occurred in various degrees of severity in way of all seven centreline tanks, six of the starboard side tanks, and two of the port side tanks.

Apart from the damage which obviously occurred when the barge capsized, there was no evidence of any prior damage or any deficiency which may have caused her to take water. The deck was apparently intact before the capsizing and all closing appliances, including companion way doors, manhole covers and sounding pipe plugs were observed or reported to have been secure.

Examination of the forepeak bilge and the centreline tanks' ballast piping and pumping arrangement revealed no evidence of damage nor of any deficiency that may have existed prior to the capsize. It was observed that a single sea suction shell opening was blanked off with a plate welded on externally. Reportedly, the bilge and ballast system had not been used for a number of years and all valves were kept in the closed position. There was neither bilge nor ballast piping installed in the port and starboard side void tanks.

The shipside overboard discharge valve was found to be easily operable by hand and, with the barge as loaded and with a slight starboard list, the shipside opening was likely to have been below the load water line at the time of the casualty. However, if this shipside valve had been open, it is unlikely that any water would have flowed into any of the centreline tanks or into the forepeak bilge because, in the case of the tanks and the bilge, respectively, either three or two other pump and/or manifold valves would have had to be open. The shipside overboard discharge opening was blanked off with a plate welded on externally before the barge was returned to service on April 23, 1987.

There had been no established procedure for sounding the various compartments, and there was no record of when any of the tanks were last sounded or had been required to be pumped out. Reportedly, some of the tanks were last inspected internally by the owner at the time of the classification society load line certificate renewal survey in October, 1984.

The "SEASPAN 240" was examined in drydock on March 24, 1987, when the draught and load line marks were checked and it was ascertained that those marks were correctly

positioned.

Examination of the barge revealed no evidence as to the cause of the capsizing.

7. Disposition of Cargo and Other Imposed Loads

(a) Cargo

Reportedly, the limestone rock cargo of 12,651 short tons (11,480 tonnes) on board at the time of the casualty was a similar load as on previous voyages and was the second largest load to have been carried. Evidence indicates that the barge was virtually upright on leaving Blubber Bay on November 17, and subsequently on arrival at Tilbury Island on November 18. Rough seas and gale force winds were encountered during the voyage but the disposition of the cargo apparently was not detrimental to the seaworthiness of the barge nor was there any shifting of cargo.

A review of the shipping invoices and the freeboard measurements taken for a number of previous voyages showed that, with only marginal discrepancies, there was normally agreement between the measurements taken at the loading facility and those taken at the cement plant.

On November 25, 1986, the freeboard measurements taken by the cement plant personnel showed an average difference of approximately 1.1 m (3.5 ft) between the port and starboard side measurements at the forward and amidship positions, indicating that the barge may have had a starboard list of some 2.5°. However, the mean freeboard of all the recorded measurements equated to a load of only 11,941 short tons (10,832 tonnes), some 700 short tons (635 tonnes) below the amount reported to have been loaded. Further, those measurements showed neither consistent lists at the three measurement positions nor a uniform trim port or starboard. Accurate measurements for the barge prior to the capsizing would have been valuable but, due to the aforementioned inconsistencies, the measurements that were taken are considered to be unreliable and those recorded on departure from Blubber Bay have been used to derive the actual deadweight and stability.

In the process of levelling out the rock peaks in preparation for unloading, the drivers of the front end loaders are required to utilize their experience and expertise in moving the rock without impairment of the stability of the barge and preparing a reasonably flat

surface to facilitate movement of the vehicles. During the operation the drivers are aware that the barge rolls due to movement of the vehicles and that she lists as a result of repositioning and removal of rock. However, in a moving vehicle on an uneven surface, the drivers were not fully aware of the true extent of such rolling and listing. The levelling operation was witnessed at the cement plant on April 29, 1987, and it was observed that, although not more than one degree, the rolling motion created by the movement of the vehicles was continuous.

Also on April 29, the draught marks on the stern of the barge were noted on arrival and they indicated there was a barely perceptible port list. When the levelling operation was completed the draught marks indicated a starboard list of approximately 1.5°. The working environment does not give the drivers a ready awareness of the small angles of heel which are associated with the comparative larger movements of the barge but the barge is now equipped with inclinometers, one on top of the after wall and one above the forecastle bulkhead, which are readily visibile to the drivers during the unloading operation.

Evidence indicates that on the day of the casualty there was a starboard list when the levelling operation was completed and, if the barge had been virtually upright before the levelling operation, a small quantity of rock was possibly, and unintentionally, moved from port to starboard. If such was the case, then the uneven disposition of the cargo could have been a contributing factor to the capsizing. It is noted, however, that the levelling operation was completed at about 1100 and apparently the barge showed no sign of capsizing until the roadway ramp was lowered on to the side wall and one vehicle was being driven ashore shortly after 1130.

(b) Rainfall

The rainfall of approximately 152 mm (6 in) at Tilbury Island from November 18 to 25 could have caused some 285 short tons (258 tonnes) of water to accumulate within the side walls of the barge. In addition, the limestone rock was crushed, stockpiled and loaded during periods of rain and would have had some degree of wetness when loaded.

If the water retention factor of the rock is not less than 2%, then the rain-water should have been somewhat evenly distributed throughout the load as a surface film

and in the crevices. However, it is considered most likely that the bulk of the rain-water percolated the rock towards the deck. If that water did not drain away through the freeing ports it is possible that upwards of 250 short tons (220 tonnes) accumulated above the deck and, with a rock permeability assumed at 20%, to a depth of approximately 0.76 m (2.5 ft) within the side walls with the vessel upright.

An accumulation of rain-water of the aforementioned amount would have been sufficient to adversely affect the stability of the barge and, as nothing else had changed aboard the vessel for six days, such a condition is considered likely to have been a significant contributing factor in the capsizing.

(c) Mooring Lines

On a rising tide all lines, depending on their tautness, would tend to impose starboard heeling moments on the barge. Reportedly, the lines had not been adjusted for some time prior to the casualty and the day before the casualty, at about the same state of tide, the after lines were observed to be taking the strain on the flood tide while the forward lines were slack.

At the time of the casualty the tide was rising and it is considered that the tension in the main springs and in some of the other lines may have been a minor but relatively insignificant factor in the capsizing.

(d) Roadway Ramp

The ramp is raised and lowered by hydraulic means with a single ram of approximately 150 mm (6 in) diameter and a fluid pressure of approximately 3000 kPa (500 p.s.i). The outboard end of the ramp is fitted with a hydraulically operated extension piece to provide for close adjustment when landed on top of the side wall of the barge.

When the ramp is in use and in position on the side wall, the hydraulic system for the operating ram is arranged to allow the ramp to rise and fall with any corresponding movement of the barge. When the ramp is not in use, the extension piece is retracted and the ramp is mechanically secured in a raised position, well clear of the side wall. There is no fixed connection between the end of the ramp and the side wall.

Evidence indicates that the weight of the ramp assembly

is some 92 short tons (84 tonnes) and, without a counterbalance mechanism, would impose a load of approximately 50 short tons (45 tonnes) on the top of the side wall. The installed counterbalance mechanism is designed to reduce the deadweight load of the ramp by 95% and the actual load on the top of the side wall is approximately 2.5 short tons (2.25 tonnes).

The front end loader weighed approximately 32 short tons (29 tonnes) and was at the end of the ramp and above the side wall when the barge started to heel immediately prior to capsizing. Reportedly, the deck edge was just immersed at that time and the barge continued heeling to starboard even though the ramp was raised clear of the side wall and the barge thereby relieved of the load. Such a situation tends to indicate that the loaded ramp was a disturbing influence which contributed to a shift of weight aboard the barge other than the limestone rock.

There was no report of any malfunction in the operation of the ramp or the counterbalance mechanism immediately prior to the capsizing. The salvaged equipment was examined but the degree of damage precluded identification of any possible mechanical failure.

(e) Conveyor Structure

The conveyor structure is raised and lowered by hydraulic means in the same manner as the roadway ramp. The conveyor hydraulic system is also arranged to allow the conveyor to rise and fall with the movement of the barge, and the conveyor is equipped with a counterbalance mechanism similar to the ramp. There is no fixed connection between the end of the conveyor and the barge and the connection is made by means of landing an inverted hollow fixture on the underside of the conveyor on to a semi-hemispherical fixture on the deck of the barge (i.e. ball and socket arrangement).

Evidence indicates that the weight of the conveyor structure is some 58 short tons (52 tonnes) and without the counterbalance mechanism would impose a load of approximately 35 short tons (32 tonnes) on the edge of the deck of the barge. The effect of the counterbalance mechanism is to reduce the load on the deck to approximately 1.75 short tons (1.5 tonnes).

In the event of a hydraulic system failure, so as to prevent the conveyor rising due to upward movement of the barge, such movement would be resisted only by the

64 mm (2.5 in) diameter extension rod from the hydraulic ram. If this had occurred, then the extension rod would have buckled and allowed the conveyor to rise when it was subjected to an upward force of approximately 2 short tons (1.8 tonnes).

There was no report of any malfunction in the operation of the conveyor or the counterbalance mechanism immediately prior to the capsizing. The salvaged equipment was examined but the degree of damage precluded identification of any possible mechanical failure.

It is noted that the end of the shore conveyor may have been 'locked' between the deck and the overlapping end of the onboard conveyor when the barge was heeled to starboard at an angle of approximately 10°. The extreme end of the onboard conveyor was observed to have been bent upwards indicating that such may have been the case, but there was no damage to the deck of the barge in the corresponding area.

It is considered that the weight of the conveyor on the deck edge of the barge was a minor contributing factor in the capsizing.

(f) Front End Loaders

The weight of the vehicle used at the forward end of the barge was approximately 34 short tons (31 tonnes) and the vehicle at the after end weighed approximately 32 short tons (29 tonnes). The weight and normal movement of the vehicles on top of a dry deck cargo during the levelling operation would not significantly reduce the transverse stability of the barge. However, in conjunction with the free-surface effect of an accumulation of rain-water within the limestone rock, their simultaneous and prolonged off-centre parked locations just prior to the capsize would induce a small angle of heel and initiate the gravitation of any rain-water to starboard. Such a situation is considered to have been a major contributing factor which eventually led to the capsize of the barge.

8. Load Line and Stability Requirements, Deadweight and Lightship Weight

The load line marks for the summer freeboard assigned to the "SEASPAN 240" in 1970 were applicable only when the barge was engaged on certain international voyages, and were submerged approximately 0.61 m (2.0 ft) in the loaded condition prior to the casualty.

However, under the Load Line Regulations (Sea) and operating at the time of the casualty between Canadian ports with no passengers, crew or oil cargo on board, the barge was not required to be assigned a load line. Consequently, compliance with the stability criteria and other conditions of STANDARD:STAB 8 (INTERIM) of the Stability, Subdivision and Load Line Standards, issued by the Canadian Coast Guard, was not required.

Prior to the issue of STANDARD:STAB 8 in 1975, the established and accepted practice for assessing the intact transverse stability of barges was primarily based upon the attainment of an adequate transverse metacentric height (GMt). Under STANDARD:STAB 8, where a barge similar to the "SEASPAN 240" is assigned a load line, it is required that the minimum value of dynamic stability (the area under the GZ curve) shall be 0.08 mR (15.00 ft°) up to the angle of heel at the maximum righting lever (GZ), or the angle of downflooding if this is lower.

While the "SEASPAN 240" was not required to comply with the stability criteria of STANDARD: STAB 8, these current requirements are mentioned in this analysis for comparison with, and to provide a clearer perspective of, the actual stability characteristics of the barge immediately before and during the casualty.

Transverse stability data incorporating lightship characteristics and two stowage rates for 10,200 long tons (11,424 short tons) of deck-loaded cargo, together with the related transverse metacentric heights of 5.97 ft (1.82 m) and 4.20 ft (1.28 m), were submitted to and approved by the Board of Steamship Inspection, June 4, 1970.

The submitted data included the following information:

Barge lightship weight = 1,790 long tons

Barge lightship vertical centre of gravity (VCG) = 17.50 ft.(5.33 m)

In 1985, following the removal of the existing wood side and end walls of the deck cargo box and their replacement with walls of steel construction, the owners prepared a new freeboard measuring guide and related cargo deadweight scale for use during loading and unloading operations. This data included an updated lightship weight, derived from draughts measured August 28, 1985, after installation of the new steel deck cargo box walls

was completed, and superseded a similar guide and scale which had been prepared after the structural and conveyor modifications of 1975.

The August, 1985, data included the following information:

Barge lightship weight = 1,962 long tons

Barge lightship draught (SW) = 3.61 ft. (1.10 m)

Reportedly, the owners' and designers' records contained no data related to any inclining experiment having been carried out prior to the time of the casualty and the basic lightship data originally submitted for approval was based upon calculated design figures.

After the casualty, when the barge had been righted and upon completion of all repairs restoring the "SEASPAN 240" to its previous operational and structural condition, an inclining experiment was carried out by the owners, April 15, 1987 and the following data obtained:

Barge lightship weight = 1,893.48 long tons

Barge lightship VCG = 4.44 m (14.56 ft)

Barge lightship LCG (fwd of ⊠) = 0.68 m (2.22 ft)

The current lightship data was developed from the inclining experiment, with due allowances made for water density and vessel trim, together with computer generated trimmed hydrostatic particulars. This data, in conjunction with the freeboards recorded prior to departure from Blubber Bay, is considered to be the most reliable combination for the derivation of the actual cargo deadweight and transverse stability characteristics prior to, and at the time of the casualty.

The current lightship weight increase, of some 103 long tons over the unverified 1970 weight, may be primarily attributed to the increases associated with the 1975 and 1985 structural, conveyor, and cargo box side wall modifications.

The decrease in the current lightship weight, from that of the 1985 weight, may be primarily attributed to the adoption of computer generated trimmed hydrostatics data in lieu of the designers' original level trim data. Because the actual lightship weight was lower than that

shown in the owners' 1985 deadweight scale in use before the casualty, the actual cargo deadweights loaded would have been at least 77 short tons (70 tonnes) greater than indicated.

All cargo deadweights included in Item 1, and the Background and Narrative sections of this report, are derived from the 1975 and 1985 deadweight scales as these reflect the basis upon which the barge was then operated.

9. **Casualty stability**

The term free surface has been employed in the following paragraphs but, rather than its commonly accepted meaning, it should be noted that, for the purpose of the calculations referred to herein, the effect of the free surface of the liquid in the cargo box has been reduced by 90%, to take into account the interference to complete free passage of liquid through the cargo.

In seeking to identify the principal source of a heeling moment of sufficient magnitude to cause the barge to capsize, the foregoing paragraphs of this analysis address the individual forces or loads which may have been acting on the "SEASPAN 240" while alongside the unloading dock, and effectively eliminate or assess their relative effects.

Although some of those forces and loads may have eventually become contributing factors, it is considered unlikely that the major cause of the capsizing was any of the following:

(i) the mooring arrangements;

(ii) the tide, river current, or wind;

(iii) contact of the barge with the river bottom;

(iv) damage to the underwater hull of the barge; or

(v) the bearing loads of the roadway ramp and the conveyor structure, either directly or as a result of the malfunction of their hydraulic and counter-balance mechanisms.

The most significant unusual influence to which the barge may have been subjected is identified as being the possible accumulation of rain-water within the limestone inside the deck cargo box, as a result of the heavy rainfall of approximately 152 mm (6 inches) throughout the week the barge was tied up and stationary.

An analysis of the transverse stability characteristics of the "SEASPAN 240" has been carried out, incorporating the currently established lightship details, together with the derived departure cargo deadweight. The analysis focuses upon the detrimental effects of an accumulation of rain-water in conjunction with the reported locations of the conveyor, roadway ramp, temporary rock ramp and the movements of the onboard vehicles.

The calculations show that upon departure from Blubber Bay, the "SEASPAN 240" was loaded with 12,750 short tons (11,570 tonnes) of limestone rock, was trimmed 0.28 m (0.92 ft) by the stern and had a metacentric height (GMt) of 1.52 m (4.97 ft). The mean salt water draught was 6.30 m (20.66 ft), the maximum righting lever (GZ) of 0.19 m (0.62 ft) was reached at 8.6° heel, and the area under the GZ curve up to 8.6° heel was 0.016 mR (2.94 ft°).

Upon arrival at the cement plant unloading dock in the Fraser River, having passed from saltwater to freshwater, the mean draught of the "SEASPAN 240" increased to 6.46 m (21.20 ft), the after trim became 0.25 m (0.81 ft), and the GMt was 1.41 m (4.62 ft). The maximum righting lever (GZ) of 0.12 m (0.40 ft), was reached at 8.25° heel, and the area under the GZ curve up to 8.25° heel was approximately 0.01 mR (2.0 ft°).

The metacentric heights of the departure and arrival loading conditions are generally in line with accepted and established practice, indicating adequate initial stability. However, the maximum righting levers (GZ) were reached at 8.6 ° and 8.25°, respectively, and comparison with the minimum requirements of STANDARD: STAB 8, although not applicable to the "SEASPAN 240" at the time of the casualty, shows that the dynamic stability (area under the GZ curve), up to the angle of heel of the maximum righting lever for the departure and arrival loading conditions, was respectively only 19.60% and 13.33% of the minimum requirement.

Calculations show how the transverse stability would have been further reduced by an accumulation of approximately 152 mm (6 in) of rain-water inside the deck

cargo box. Based upon volumetric and horizontal surface permeabilities of 20% and 10% respectively, the weight and free-surface effect of approximately 285 short tons (258 tonnes) of rain-water just above deck level would increase the mean draught to 6.57 m (21.56 ft) and reduce the GMf to 0.96 m (3.14 ft).

When the barge was alongside the unloading dock, the transverse stability was further adversely affected by the weight of the two front end loaders which were driven on top of the deck cargo. Reportedly, throughout the unloading preparations, the barge generally remained upright but rolled slightly to port and starboard as the vehicles rearranged and levelled the surface of the deck cargo. It is likely that the apparent inconsistencies of the freeboards variously observed just before the capsize may be attributed, in part, to this slow induced rolling. However, the rolling would not have allowed sufficient time for any accumulated rain-water to percolate exclusively towards one side but rather to flow between the small rocks on both sides of the barge centreline.

Calculations show the mean draught of the barge while in this condition to have been 6.60 m (21.65 ft), the GMf 0.93 m (3.04 ft), the maximum righting lever (GZ) 0.073 m (0.24 ft) at 5.5° heel, and the range of positive stability to be limited to only 10°.

From about 1125 until 1130, when both vehicles were temporarily parked close to the starboard side wall of the deck cargo box while the drivers received further working instructions and the conveyor was bearing on the starboard side deck, the barge was subjected to a heeling moment of some 520 tonne m (1,677 ft tons), which was sufficient to cause an initial heel to starboard of 2.32°. Further, as the vehicle operator on shore then lowered the roadway ramp on to the top of the starboard side wall of the deck cargo box and one vehicle was manoeuvred to create a rock ramp to facilitate disembarkation, this heeling moment would have been substantially maintained for approximately 7 minutes.

In this event, the heel of 2.32° was maintained long enough for the surface of any accumulated rain-water to percolate the crevices between the limestone rocks and gravitate to starboard. The weight of water gravitating to the initial heel of 2.32° is estimated to have been approximately 37.3 short tons (33.8 tonnes), increasing the total heeling moment to 967 tonne m (3,122 ft tons), which was then sufficient to induce a heel of 4.33°. In

turn, this induced heel ensured that any rain-water would continue to gravitate to starboard, progressively increasing the heeling moment and angle to 1,354 tonne m (4,370 ft tons) and 6.04° respectively. The righting ability of the barge, reduced because of the free-surface effect of the accumulated rain-water, was such that the maximum righting lever (GZ) of 0.073 m (0.24 ft) at 5.5°, in conjunction with the loaded displacement, provided a maximum righting moment of only 1,010 tonne m (3,262 ft tons). Thus, because the maximum righting moment was exceeded as the heeling moment continued to increase, the barge would heel slowly to starboard and having lost positive transverse stability on passing 10° heel would continue heeling at an accelerating rate.

At the time of the casualty, as the heel increased the angle of repose of the limestone rock was exceeded and the deck cargo shifted to starboard and/or fell overboard. Consequently, because of the rapid release of deadweight and the leverage of the remaining cargo acting on the then nearly horizontal starboard side wall of the deck cargo box, the sudden impetus of the resulting buoyant upthrust caused the barge to surge upward and completely capsize on to the adjacent dock.

By way of comparison, and in order to provide a clearer perspective of the casualty, separate calculations show that approximately 335 short tons (305 tonnes) of salt water flooding into the starboard side void tanks would have been required to capsize the barge when loaded with a similar, but dry, deck cargo. No source of leakage into the starboard side void tanks before the capsizing was identified and, if this had been the case, the heeling effect resulting from such hypothetical flooding would have become apparent relatively slowly.

The lack of warning and the rapidity of the actual capsize are typical indications of a sudden and dramatic loss of transverse stability due to the presence of a substantial free-surface effect and a subsequent shift of slack liquid.

While the presence and actual quantity of an accumulation of rain-water cannot be conclusively proven, the predominant influence of the free-surface effect of such accumulation, in conjunction with the verified cargo deadweight and related freeboard, makes it the most likely cause of the capsize.

10. Current operation

Calculations show that the limitation of the cargo deadweight to a maximum of 10,750 short tons (9,755 tonnes), adopted by the owners since the casualty, ensures that the dynamic stability of the barge now meets the requirements of STANDARD:STAB 8, and that a substantial margin of positive transverse stability would be retained in fresh water and salt water operations should a similar accumulation of rain-water recur.

11. Life-saving Equipment

The cement plant dock was equipped with the requisite number of lifebuoys with lines. Company policy requires that approved personal flotation devices (P.F.D.) shall be worn by personnel engaged in docking or unloading operations when crossing between the dock and a vessel, and while working adjacent to the dock face or an unguarded deck edge.

The drivers of the front end loaders do not normally wear a P.F.D. while operating vehicles on board a vessel during the levelling and unloading operations and there is no requirement or regulation for them to do so. Reportedly, the drivers generally stow the P.F.D.'s in the cabs of the vehicles while they are driving.

12. Reporting of the Casualty

Although the casualty was reported by the shipper and the owner to two branches of the Canadian Coast Guard shortly after the occurrence, it was not reported to the proper authorities in accordance with the requirements of the Shipping Casualties Reporting Regulations (see Annex I). As a result, the Marine Casualty Investigations Division, Department of Transport, was not advised of the casualty until three days after the occurrence.

Findings

The "SEASPAN 240" capsized while secured alongside the dock, in good weather and during preparation for the discharge of a cargo of limestone rock. It would appear that the cause was a loss of transverse stability due to the free-surface effect and gravitation to starboard of an accumulation of water inside the cargo box. Although this cause is not unequivocally proven, the most likely contributing factors were as follows:

- the barge was heavily loaded;

- there was no weather protection for the limestone rock cargo nor is any required by regulation;

- the barge was subjected to heavy weather at sea and a heavy rainfall during some seven days while alongside the dock;

- the obstruction of the drainage arrangements (freeing ports) in the cargo box side walls by compacted deposits of limestone;

- the retention of sea and rain-water inside the cargo box;

- possible and unintentional movement of limestone rock towards the starboard side of the barge during the levelling operation;

- positioning of the two front end loaders on the starboard side, creating a heeling moment and promoting the flow of any water retained inside the cargo box to that side; and

- the starboard heeling moments created by the rock ramp prepared for disembarkation of the front end loader, the bearing weights of the loaded roadway ramp and the conveyor structure, and the restraining effect of the mooring lines.

Other Findings

The Load Line Regulations (Sea) did not apply to the "SEASPAN 240" at the time of the casualty and the summer load line mark assigned under those Regulations, indicating her appropriate carrying capacity on international voyages, was submerged some 0.61 m (2.0 ft) on the voyage from Texada island to the Fraser River.

Because a load line was not required to be assigned for the voyage, the loaded barge did not have to comply with, nor did she meet, the stability criteria and other conditions of STANDARD:STAB 8 (INTERIM) of the Stability, Subdivision and Load Line Standards issued by the Canadian Coast Guard.

It would appear that this casualty could have been averted and the consequential threat to life eliminated if the barge had been loaded so as to meet the stability criteria applicable to barges engaged in similar service

on international voyages.

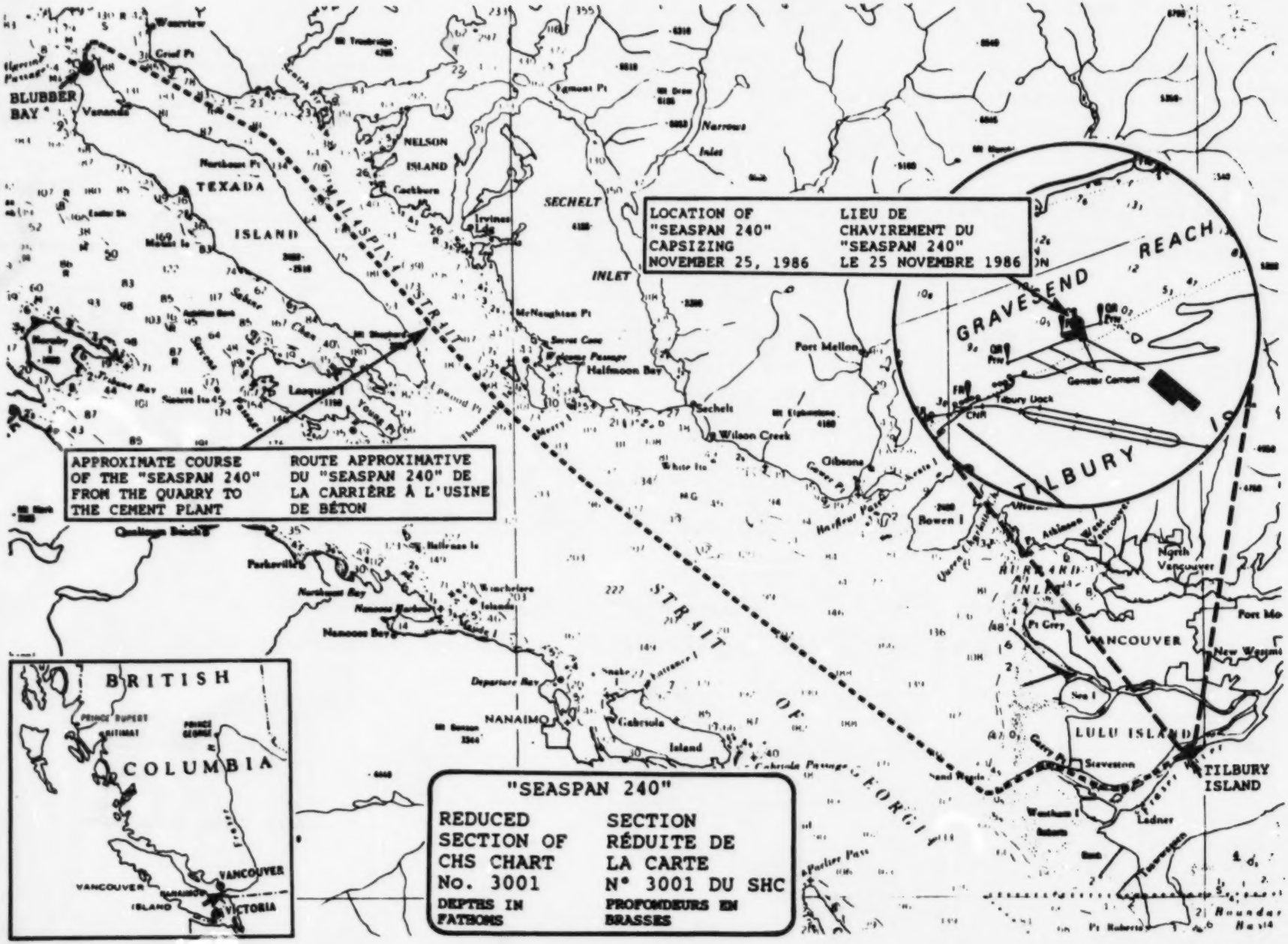
The barge appeared to have been intact prior to the capsizing, with respect to the hull, the bilge and ballast piping systems, and the watertight closing appliances.

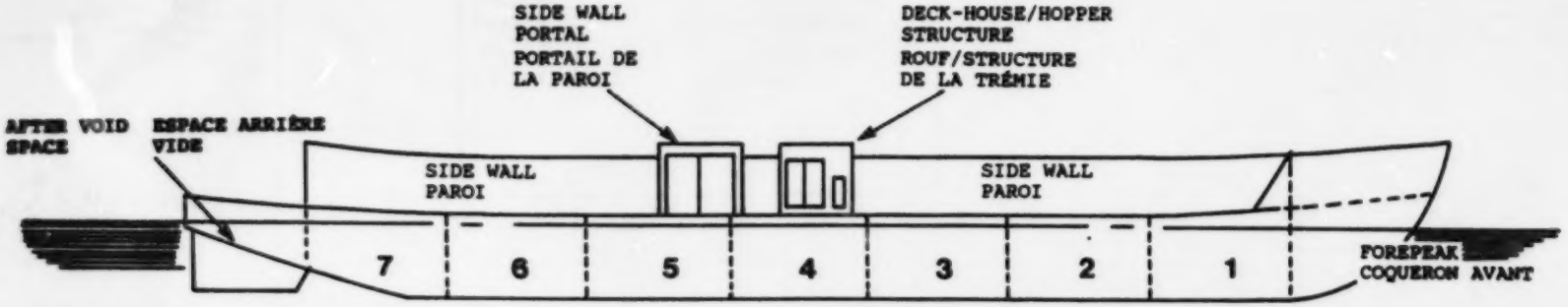
No deficiencies were identified as having existed prior to the capsizing in the mooring arrangements or the unloading facility and associated equipment.

The drivers of the front end loaders did not wear personal flotation devices (P.F.D.) while operating the vehicles during the levelling operations, nor is there any requirement for them to do so.

The casualty was not reported in accordance with the requirements of the Shipping Casualties Reporting Regulations.

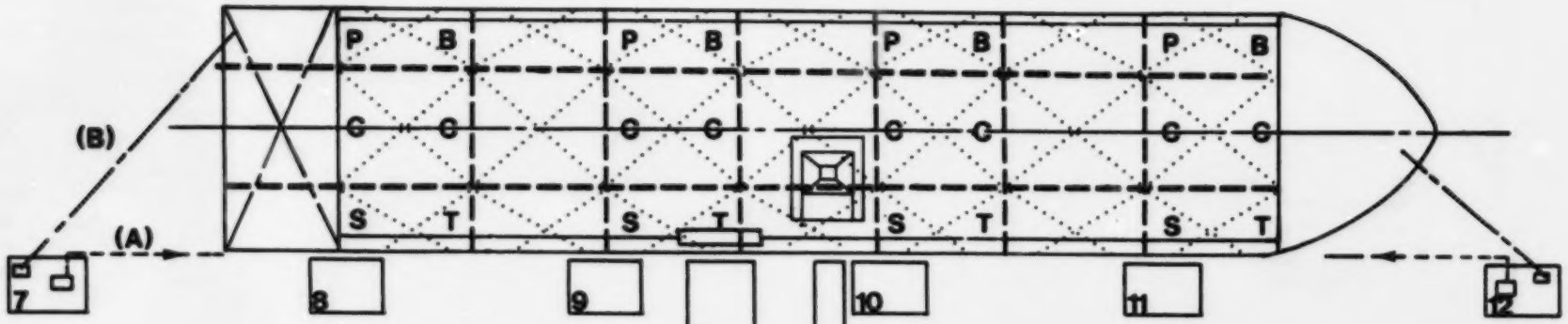
OTTAWA, ONTARIO
AUGUST, 1988.


LOCATION OF "SEASPAN 240" CAPSIZING NOVEMBER 25, 1986
LIEU DE CHAVIREMENT DU "SEASPAN 240" LE 25 NOVEMBRE 1986
APPROXIMATE COURSE OF THE "SEASPAN 240" FROM THE QUARRY TO THE CEMENT PLANT
ROUTE APPROXIMATIVE DU "SEASPAN 240" DE LA CARRIÈRE À L'USINE DE BÉTON
BRITISH COLUMBIA
"SEASPAN 240"
REDUCED SECTION OF CHS CHART No. 3001
SECTION RÉDUITE DE LA CARTE N° 3001 DU SHC
DEPTHS IN FATHOMS
PROFONDEURS EN BRASSES
BLUBBER BAY
TEXADA ISLAND
NELSON ISLAND
SECHELT INLAND
GRAVESEND REACH
TILBURY ISLAND
LULU ISLAND
VANCOUVER
NANAIMO
STRAIT OF GEORGIA



DIAGRAMMATIC ARRANGEMENT OF "SEASPAN 240" AND LOADING BERTH

DISPOSITION SCHÉMATIC DU "SEASPAN 240" ET DU QUAI DE DÉCHARGEMENT



DOLPHINS 7 & 12 - WITH ELECTRIC/HYDRAULIC WINCHES FOR FORWARD AND AFTER MAIN SPRINGS (A)

DUCS D'ALBE 7 & 12 - ÉQUIPÉS DE TREUILS ÉLECTRO-HYDRAULIQUES POUR LES GARDES MONTANTES AVANT ET ARRIÈRE (A)

DOLPHINS 7 & 12 - WITH "BEE BEE" WINCHES FOR BOW AND STERN LINES (B)

DUCS D'ALBE 7 & 12 - ÉQUIPÉS DE TREUILS "BEE BEE" POUR LES AMARRES DE L'AVANT ET DE L'ARRIÈRE (B)

ROADWAY RAMP

RAMPE DE LA CHAUSSÉE

CONVEYOR

CONVOYEUR À BANDE

GANTRY WITH LIFTING LOWERING AND COUNTER-BALANCE MECHANISMS

SUPPORT DE LA STRUCTURE MUNI D'UN DISPOSITIF DE LEVAGE/D'ABAISSEMENT ET D'UN MÉCANISME DE CONTREPOIDS

DOLPHINS 8 & 11 - WITH POWER CAPSTANS FOR POLYPROPYLENE SPRINGS

DUCS D'ALBE 8 & 11 - ÉQUIPÉS DE CABESTANS MOTORISÉS POUR LES GARDES MONTANTES EN POLYPROPYLÈNE

DOLPHINS 9,10 & 12 - WITH BOLLARDS FOR ADDITIONAL POLYPROPYLENE LINES

DUC D'ALBE 9,10, & 12 - ÉQUIPÉS DE BOLLARDS POUR LES AMARRES DE POLYPROPYLÈNE ADDITIONNELLES

FIGURE 1

ANNEX

CANADA SHIPPING ACT

Shipping Casualties Reporting Regulations

P.C. 1985-1804 30 May, 1985

Short Title

1. These Regulations may be cited as the *Shipping Casualties Reporting Regulations*.

Definitions

2. In these Regulations,

"Canadian radio ship reporting station" means a Canadian Coast Guard radio station or a Canadian Vessel Traffic Service Centre of the Department of Transport, a Canadian marine radio station operated by the St. Lawrence Seaway Authority or a Canadian harbour radio station; (*station de radiocommunications maritime canadienne*)."

Application

3. These Regulations apply to all ships in Canadian waters and to all Canadian ships in any waters.

Preliminary Report

4. (1) Where a ship, or a vessel being towed by a ship, is involved in a shipping casualty, an accident or a dangerous occurrence, the master, any certificated officer, operator, member of the crew, pilot or person responsible for the ship, or the vessel being towed, shall report the incident without delay in accordance with subsections (2) and (3)."

(2) Subject to subsection (3), the report referred to in subsection (1) shall be made without delay

(*a*) by radio communication to a Canadian radio ship reporting station, where the shipping casualty, accident or dangerous occurrence takes place in Canadian waters or on a voyage to or from a Canadian port or alongside a port facility in a Canadian port; or

(*b*) where the shipping casualty, accident or dangerous occurrence takes place outside the range of a Canadian radio ship reporting station, to

(i) any other radio ship reporting station,

(ii) a chief officer of customs or the superintendent of a mercantile marine office, if the location is in a Commonwealth country other than Canada, or

(iii) a Canadian consular officer, if the location is a place other than a place referred to in subparagraph (ii).

APPENDICE

LOI SUR LA MARINE MARCHANDE DU CANADA

Règlement sur les rapports de sinistres maritimes

C.P. 1985-1804 30 mai 1985

Titre abrégé

1. *Règlement sur les rapports de sinistres maritimes.*

Définitions

2. Les définitions qui suivent s'appliquent au présent règlement.

«station de radiocommunications maritime canadienne» Station radio de la Garde côtière canadienne ou centre de Service du trafic maritime du Canada du ministère des Transports, station radio maritime canadienne exploitée par l'Administration de la voie maritime du Saint-Laurent ou station radio d'un port canadien. (*Canadian radio ship reporting station*).»

Application

3. Le présent règlement s'applique à tous les navires se trouvant dans les eaux canadiennes et à tous les navires canadiens, quelles que soient les eaux dans lesquelles ils se trouvent.

Rapport préliminaire

4. (1) Lorsqu'un navire ou un bâtiment remorqué par un navire est impliqué dans un sinistre maritime, un accident ou un événement dangereux, le capitaine, un officier breveté, l'exploitant, un membre de l'équipage, le pilote ou toute personne responsable du navire ou du bâtiment remorqué doit en faire rapport sans délai, conformément aux paragraphes (2) et (3).

(2) Sous réserve du paragraphe (3), le rapport visé au paragraphe (1) doit, selon le cas:

a) être communiqué sans délai par radio à une station de radiocommunications maritime canadienne, lorsque le sinistre maritime, l'accident ou l'événement dangereux se produit pendant que le navire est amarré à une installation portuaire dans un port canadien ou se trouve en eaux canadiennes, ou se produit au cours d'un voyage à destination ou en provenance d'un port canadien;

b) lorsque le sinistre maritime, l'accident ou l'événement dangereux se produit à un endroit à l'extérieur de la portée d'une station de radiocommunications maritime canadienne, être communiqué sans délai:

(i) soit à une autre station de radiocommunications maritime,

(ii) soit à un préposé en chef des douanes ou au surintendant d'un bureau de la marine marchande, si l'endroit est situé dans un pays du Commonwealth autre que le Canada,

(iii) soit à un fonctionnaire consulaire du Canada, si l'endroit est un endroit autre que celui visé au sous-alinéa (ii).

Written Report

5. (1) Where a ship is involved in a shipping casualty, an accident or a dangerous occurrence, the master, any certificated officer, operator, member of the crew or person responsible for the ship shall

(*a*) within 24 hours of the occurrence of the incident or as soon as possible thereafter, make a written report on the incident, including a statement as to its probable cause; and

(*b*) forward the report by air mail without delay to the Chief, Marine Casualty Investigations, Department of Transport, Ottawa."

(2) The report referred to in subsection (1) shall

(*a*) be made on the form set out in the schedule; and

(*b*) where possible, be completed

(i) in Canada, in the presence of a chief officer of customs, a Department of Transport marine casualty investigations officer, a Canadian Coast Guard ship safety officer or any other Department of Transport Coast Guard officer, or, where none of these persons is available, a Royal Canadian Mounted Police officer.

(ii) in another Commonwealth country, in the presence of a chief officer of customs or the superintendent of a mercantile marine office, or

(iii) in a country other than a country referred to in subparagraph (i) or (ii), in the presence of a Canadian consular officer.

Rapport écrit

5. (1) Lorsqu'un navire est impliqué dans un sinistre maritime, un accident ou un événement dangereux, le capitaine, un officier breveté, l'exploitant, un membre de l'équipage ou toute personne responsable du navire doit

a) d'une part, rédiger un rapport de l'incident, comprenant une description de ses causes probables, dans les 24 heures suivant le moment où il s'est produit, ou aussitôt que possible;

b) d'autre part, adresser sans délai ce rapport, par voie aérienne, au chef des Enquêtes sur les accidents maritimes, ministère des Transports, à Ottawa.

(2) Le rapport visé au paragraphe (1) doit à la fois:

a) être rédigé sur le formulaire figurant à l'annexe;

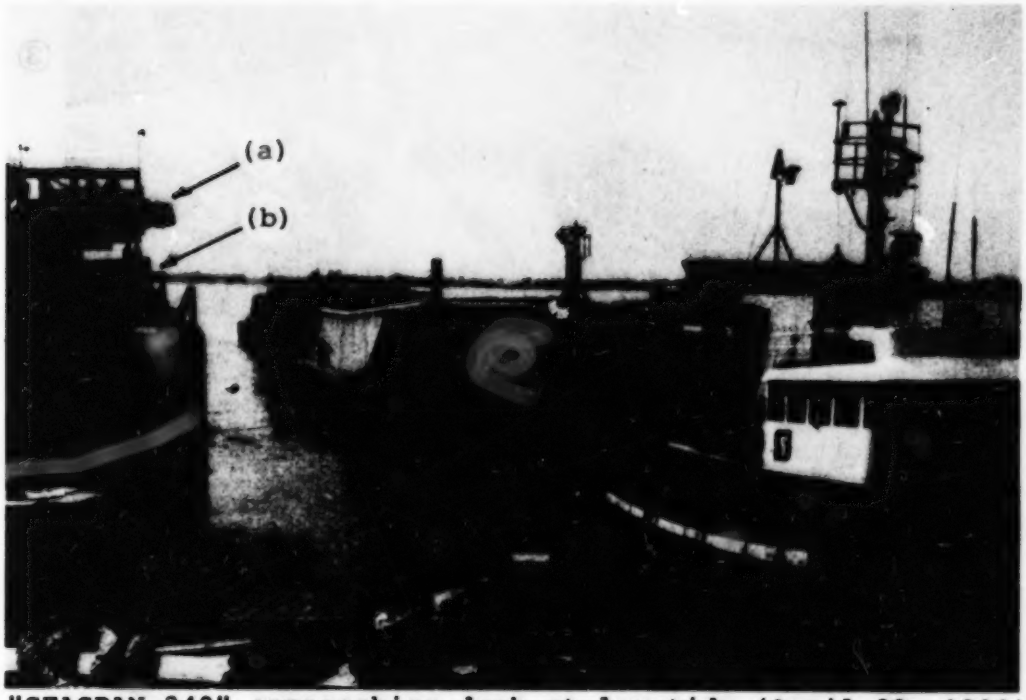
b) être, dans la mesure du possible, établi:

(i) soit au Canada, en présence d'un préposé en chef des douanes, d'un agent des services d'enquête sur les accidents maritimes du ministère des Transports, d'un inspecteur de navires de la Garde côtière canadienne ou de tout autre agent de la Garde côtière du ministère des Transports, ou d'un agent de la Gendarmerie royale du Canada si aucune des personnes susmentionnées n'est présente,

(ii) soit dans un autre pays du Commonwealth, en présence d'un préposé en chef des douanes ou d'un surintendant d'un bureau de la marine marchande,

(iii) soit dans un pays non visé aux sous-alinéas (i) et (ii), en présence d'un fonctionnaire consulaire du Canada.

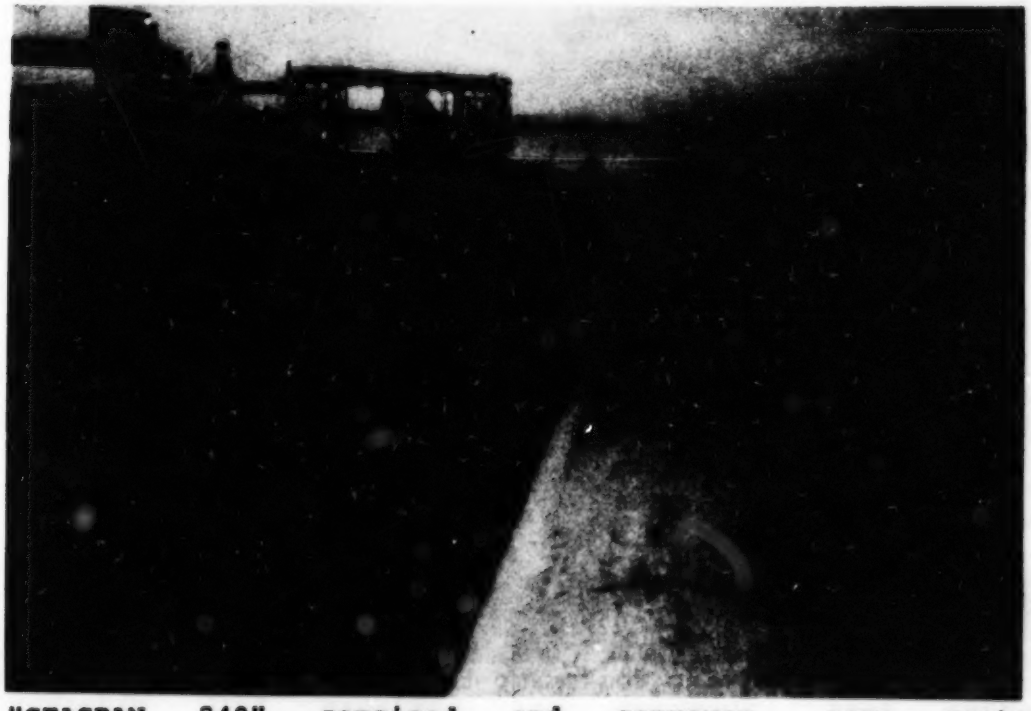
①



"SEASPAN 240" approaching dock at low tide (April 29, 1988). a) Conveyor structure. b) Roadway ramp.

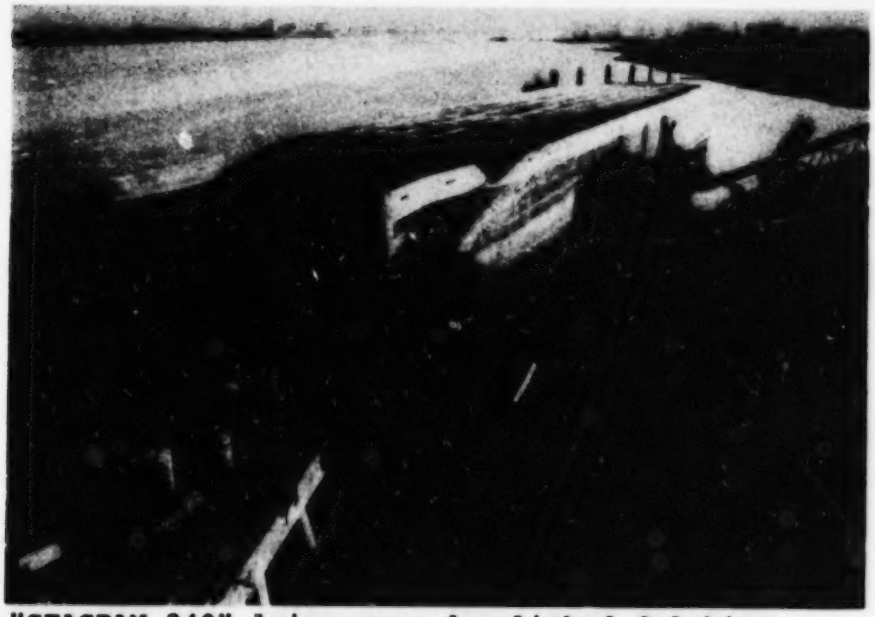
"SEASPAN 240" approchant le quai à marée basse (le 29 avril 1988). a) Structure du convoyeur à bande. b) Rampe de la chaussée.

②



"SEASPAN 240" capsized and conveyor, ramp, gantry and counterbalance mechanisms collapsed.

Le convoyeur à bande, la rampe, le support et le mécanisme de contrepoids s'effondrent suite au chavirement du "SEASPAN 240".



③

"SEASPAN 240" lying over demolished dolphins.

"SEASPAN 240" appuyé sur les ducs d'albe démolis.

④

Front end loader forming rock ramp to go on board.

Tracto-chargeur prépare une rampe en gravier pour monter à bord.

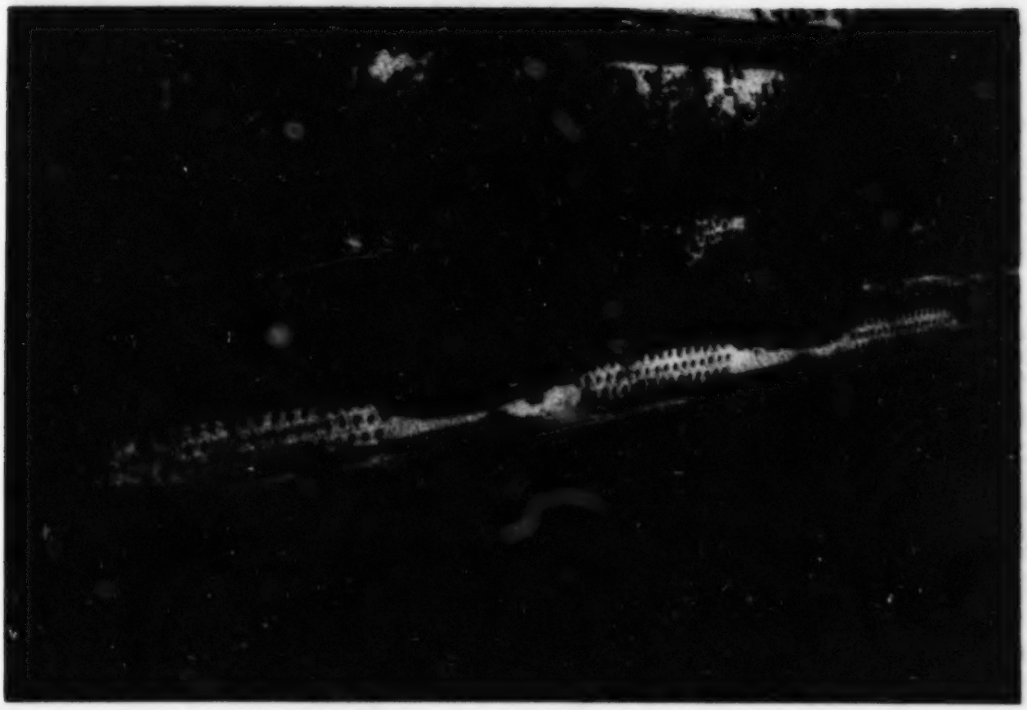
Showing conveyor in position on edge of deck and roadway ramp pulled clear of side wall.

Convoyeur en position sur le bord du pont et la rampe de chaussée dégagée de la paroi du mur.

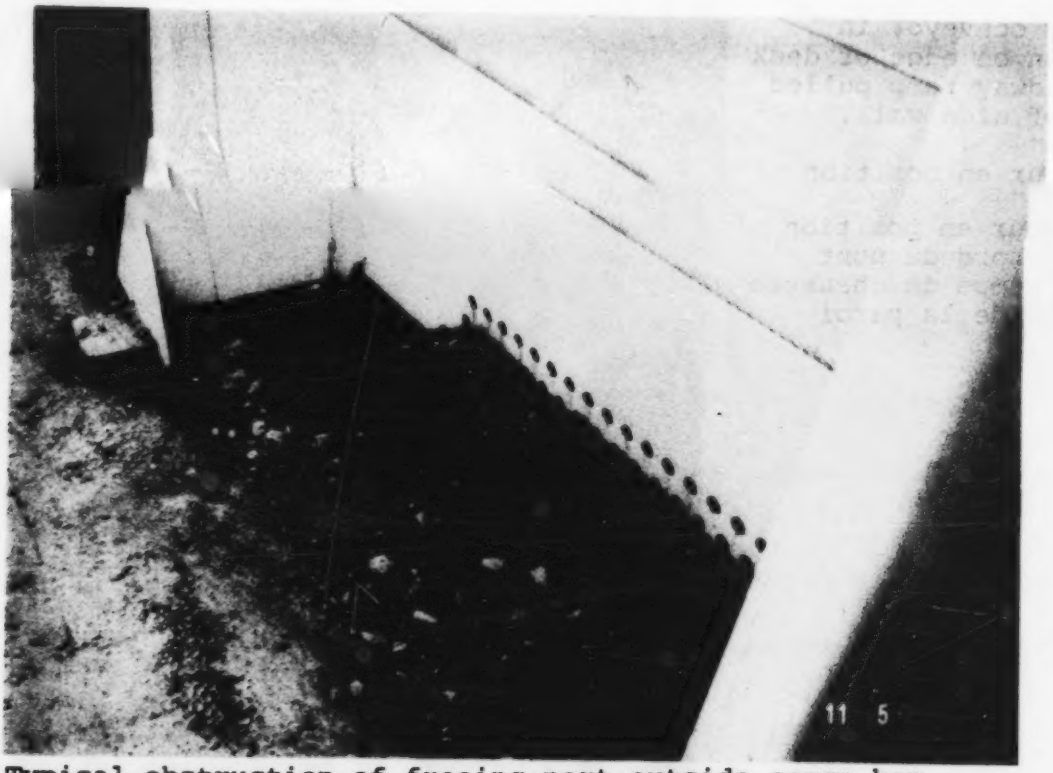
⑤

Drainage arrangements (freeing ports) viewed from inside cargo box while barge under repair.

Système de drainage (sabord de décharge) vu de l'intérieur de la cale pendant les réparations du chaland.



⑥



⑦

Typical obstruction of freeing port outside cargo box.
(mainly fine material leaked through slots and holes)

Obstruction typique qui bouche le sabord de décharge à l'extérieur de la cale.
(en grande partie c'est la matière fine qui passe à travers les fentes et les trous)

⑧

Obstruction of freeing port outside cargo box.
(accumulation of leaked fine material and spilled rock)

Obstruction du sabord de décharge à l'extérieur de la cale.
(accumulation de matière fine et de roche répandue)